

15 FEB 1990

EXCHANGED  
GENERAL LIBRARY

# Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano

Vol. 130 (1989), n. 12, pagg. 177-188

Milano, novembre 1989

Anna Alessandrello (\*) &amp; Giorgio Teruzzi (\*\*)

SRN 80080

## New outcrops with dinosaurs trackways in the Cretaceous of the Agadez region (eastern Niger)

**Abstract** — We describe herewith new outcrops with dinosaur footprints west of the Teguidat'n Tagait oasis, 80 Km north-west of Agadez (eastern Niger). We illustrate in particular a large slate showing over three hundred footprints of Coelurosaurs, that can be assigned to twenty-six different sequences. These fossiliferous outcrops are included in the formations of Irhazer Shales (Lower Cretaceous) and of Assaouas Sandstones (Upper Jurassic-Lower Cretaceous boundary).

**Riassunto** — Nuovi affioramenti con impronte di dinosauri nel Cretacico della regione di Agadez (Niger orientale).

Vengono descritti nuovi affioramenti con impronte di dinosauri a W dell'oasi di Teguidat'n Tagait, 80 Km a NW di Agadez (Niger orientale). Viene descritta in particolare una grande lastra con oltre trecento impronte di celurosauri riconducibili a 26 differenti sequenze. Gli affioramenti fossiliferi sono contenuti nelle formazioni delle Argille dell'Irhazer (Cretacico inferiore) e delle Arenarie di Assaouas (Giurassico superiore-Cretacico inferiore).

**Key words:** dinosaurs, footprints, Niger, Cretaceous.

---

(\*) Collaboratore del Museo Civico di Storia Naturale di Milano.

(\*\*) Museo Civico di Storia Naturale di Milano.

## Introduction

In the Agadez region, in centre-eastern Niger, largely outcrop continental formations known as a whole as Continental Intercalaire. In this area, the deposition of such formations began in the Permian and ended in the Lower Cenomanian (Greigert & Pognet, 1967; Taquet, 1976). Many of the formations constituting the Continentale Intercalaire preserve fossiliferous deposits, i.e. they contain skeletal remains of continental vertebrates as well as footprints.

The most famous palaeontological deposit of this region is undoubtedly that of Gadoufaouà, about 150 Km south-east of Agadez, where there were several findings of remains of Aptian vertebrates, also including numerous skeletons of iguanodontids, crocodiles etc. in anatomical connection (Taquet, 1976). In the same area there are however many places where scattered remains of vertebrates were recorded; Ginsburg et alii (1966) reported the occurrence in some of those places, west and northwest of Agadez, of tetrapod footprints, mostly dinosaurs. In 1966, these areas were in fact visited by a French palaeontological mission, which followed the first recordings made by the geologists of Commissariat à l'Energie atomique. On the occasion, French palaeontologists examined several outcrops surrounding Mount Arli, 150 Km west of Agadez where, in the formation of the Irhazer Shales ascribed to Upper Jurassic-Lower Cretaceous, they discovered a spectacular sequence consisting of thirty-one pairs of footprints, that were classified as belonging to a large Sauropod.

In the neighbourhood of Azog, north-west of Agadez, another finding was made, consisting of about sixty tridactyl footprints with dimensions ranging from 20 to 40 cm, that were attributed to Coelurosaurs and Carnosaurs by the French palaeontologists. They reported a total amount of about three hundred footprints for all the outcrops they visited, mostly belonging to dinosaurs, both in the outcrops of the Sandstones of Assaouas (ascribed to the Cretaceous according to Taquet, 1976), of Azog and of Anou Aguerouf, and in the outcrops of the already mentioned Irhazer Shales on Mount Arli, which lie below the former or with which they sometimes appear to be heteropic.

In this paper we want to describe some new localities with dinosaur footprints, that we were able to inspect during a mission in the period June-July 1987. This mission was organized by Centro Studi Archeologia Africana, Milan, following the announcement made by Giancarlo Arcangioli of the existence of new outcrops containing tetrapod footprints.

## The new outcrops

### Teguidat'n Tagait

About 3 Km west of the small Teguidat'n Tagait oasis (approximately 80 Km north-west of Agadez) and about 20 Km off the locality of Azog, where Ginsburg et alii (1966) signalled the presence of some outcrops, we were able to examine an outcrop of Irhazer Shales consisting of a bed of reddish shales. The bed surface shows a dense net of mud cracks with secondary fill, and it appears as a slate slightly sinking westward and stretching out in north-south direction. It is an irregularly shaped outcrop, 54 m long and max. 11,5 m wide. The bed surface is literally all covered with Theropod tridactyl foot-



prints, up to 3 cm deep, the majority of which are almost well preserved, belonging to 26 trackways. The length of such footprints ranges from 19 cm to 33 cm. They have different shapes: the angles between digit II and digit III, and between digit III and digit IV may vary quite considerably; the reason for this is not due in most cases to specific differences among trackmakers but, most likely, to the distinct conditions of the substratum and/or of the gait, since these differences can be found in footprints belonging to the same sequence (cf. fig. 7 b-c). These footprints always preserve very sharp impressions of digits II, III and IV as well as of «heel», with the sole exception of a sequence (sequence R) of nine footprints, where just the impressions of the three digits and of the pads of metatarsofalangeal joint are preserved.

We calculated a total amount of 312 footprints, out of which only 4 cannot be assigned to any sequence. It is possible to determine 26 sequences, 7 of them consisting of a single pair of imprints, whereas the most complete sequence includes up to 25 footprints.

Such sequences almost always appear to be rectilinear without any evident preferential direction, as they intersect in all directions.

Only in one case (sequence U) we were able to observe a sequence of 18 steps drawing a 180° arc where, by measuring the step length, one can assume the speed decrease along the curve of the trackmaker.

We have applied the Alexander formula (Alexander, 1976) to some sequences, in order to compute the speed expressed in  $\text{ms}^{-1}$ . For this purpose, we have selected the sequences that showed the most regular stride length and the largest number of steps (our selection includes sequences ranging from a minimum of five to a maximum of twenty-five steps), using a mean stride. The ratio between footprint length and hip height, to which Alexander gives a mean value of 0,25 in biped dinosaurs, is perfectly acceptable also in our case. These imprints can be assigned, as described further on, to Coelurosaurs of the type *Elaphrosaurus*. The ratio between autopodium and hip height, that can be determined on the skeletal restoration made by Janensch (1925) for *Elaphrosaurus bambergi* Janensch, 1920, corresponds to the mean ratio adopted by Alexander. The speeds computed with this procedure on a sample group including nine different trackways vary from a minimum of  $1,33 \text{ ms}^{-1}$  to  $2,41 \text{ ms}^{-1}$  (that is from 4,78 Km/h to 8,676 Km/h).

No other distinct type of footprint appears on the slate. About 2 Km farther to west, we observed other bed surfaces outcropping with the same slight inclination to the west. They bear tetrapod footprints of the same type that however, in this case, are considerably less defined than the others, since they are likely to be under-tracks; here, rocks consist of fine Assaouas Sandstones. Small scattered outcrops (just a few square metres large) of Irhazer Shales containing some footprints were also found following to the north the outcrop direction of the largest slate.

### Ain Salem

In the bed of a wadi, we came across other two outcrops, a few hundred metres away from each other, of Assaouas Sandstones, that will be referred to Ain Salem 1 (AS1) and Ain Salem 2 (AS2). AS1 is a large, irregularly shaped rocky outcrop stretching for several dozens of metres. It shows the richest

variety and density of footprints; in some points, the ground is indeed completely covered with impressions. These footprints are not well defined, since they are most likely to be under-tracks. It is possible to recognize several footprints of large-sized Sauropods, that here appear as not very deep, roughly circular troughs. The impression of a left hind limb is about 60 cm wide, whereas that of a fore limb is 22,5 cm wide; therefore, these footprints are of the same order of magnitude as the best preserved among those found by the French palaeontologists at Azog.

In addition, there are larger Theropod footprints (a tridactyl type has a maximum length of 35 cm, Fig. 4a, b, e), that resemble those observed in numerous outcrops by Ginsburg et alii (1966 - fig. 1 D). Haubold (1971) assigned these imprints to *Eubrontes* sp.. Another type of footprints that we were able to observe in this locality cannot be assigned to dinosaurs but, most probably, to a crocodile: it is one isolated, poorly preserved footprint, where digit I (?) is rather short and protrudes outwards at right angle to the other digits, which appear to be rather long and tapering.

Ain Salem 2 lies about 1 Km north of the formation described above: also in this case it is an outcrop of greyish sandstone embedded in a wadi bottom. In this outcrop it was possible to observe a sequence of five well-marked Carnosaur footprints (Fig. 4c, d, f, g and Fig. 7b, c), with a maximum length of a 40 cm, and a maximum depth of 5 cm. The sequence stops in the point where the bed is covered by the layers, that have not been yet eroded. In this site, like in AS1, Irhazer Shales outcrop a few dozens of centimetres above the bed containing the impressions, with clearly defined ripple marks.

## Comparisons and Conclusions

These footprints are preserved in the lowest third of the Irhazer Shales, whereas scattered skeletal remains of dinosaurs and crocodiles (Lapparent, 1960; Taquet, 1976) come from the intermediate layers and from the upper third. On the basis of such findings, Ginsburg et alii (1966) attributed the footprints of large Theropods to *Carcharodontosaurus saharicus*, whereas Haubold (1971) included them, as already mentioned, in the ichnogenus *Eubrontes* Hitchcock, 1845. The smallest three-digit impressions of the same type as those we found at Teguidat'n Tagait (but this is our supposition, since they were not illustrated by the French authors) have been recognized as those of large Coelurosaurs, and in particular of *Elaphrosaurus*. According to Leonardi (pers. com.) trackways B, R, C, K, L, W, X and possibly M and Y (see fig. 1, 2, 3), seem to belong to a same ichnospecies, with L being the better preserved and the more typical. This form can be attributed, for the slender and elongated type of imprints (with the digit III distally narrow and proximally spatulated) to a big Coelurosaur, of the same type of *Elaphrosaurus*, although an attribution to a medium-sized Carnosaur with relatively slender digits cannot be excluded, owing to the relative length of the footprints and the relative shortness of digit III.

The author of trackway R (see fig. 2) seems to show a different gait, with more opened digits, and his metatarsal region was in less contact with the soil. Only trackway U (see fig. 3) seems to belong to a different, though related form, more typically coelurosauroid, having digit III longer and slender than other forms, and the whole three digits are in general slender.



The footprints considered to be as of big Sauropods were instead assigned by the French authors to *Rebbachisaurus tamesnesis*, a Sauropod whose only post-cranial skeletal remains have been reported.

These new findings confirm what the preceding authors had supposed, that is that the strip of continental sediments of the Upper Jurassic-Lower Cretaceous west and north-west of Agadez appears to be a rich research ground, that deserves further close investigations.

## Acknowledgements

The authors express their best thanks to the Centro Studi Archeologia Africana, Milan, that financed and organized the mission, and to Mr Giancarlo Arcangioli for reporting the outcrop of Teguidat'n Tagait and for leading the mission. We would also like to extend our grateful acknowledgements to the other two members of the mission, who contributed actively to its success: Egiziano Piersantini and Viviana Arcangioli.

A special thank is due to Prof. Giuseppe Leonardi for his critical examination of the manuscript and of the drawings.

## References

- Alexander R. McN., 1976 - Estimates of speeds of dinosaurs. *Nature*. Londra, 126: 129-130.
- Ginsburg L., Lapparent A. F. de, Loiret B. & Taquet P., 1966 - Empreintes de pas de Vertébrés tétrapodes dans les sé continentales à l'Ouest d'Agadès (Republique du Niger). *C. R. Acad. Sc. Parigi*, 263 ser. D: 28-31.
- Greigert J. & Pognet R., 1967 - Essai de description de formations géologiques de la République du Niger. *Mem. B.R.G.M.* Parigi, 48: 1-236.
- Haubold H., 1971 - Ichnia Amphibiorum et Reptilorum fossilium. In *O. Kuhn, Handbuch der Palaoherpetologie*. Stoccarda, Part 18: 1-124.
- Janensch W., 1925 - Die Coelurosaurier und Theropoden der Tendaguruschichten Deutsch-Ostafrikas. *Palaeontographica*. Stoccarda, Suppl. VII, 1 (1): 1-99.
- Leonardi G. ed., 1987 - Glossary and Manual of Tetrapod Footprint Palaeoichnology. *Brasil. Dep. Nac. Produç. Mineral.*, Brasília.
- Lapparent A. F. de, 1960 - Les Dinosauriens du «Continental intercalaire» du Sahara central. *Mem. Soc. géol. Fr.* Parigi, (n.s.), 88.
- Taquet P., 1976 - Géologie et Paléontologie du gisement de Gadoufaouà (Aptian du Niger). *Cahiers de paléont.* Parigi: 1-191.

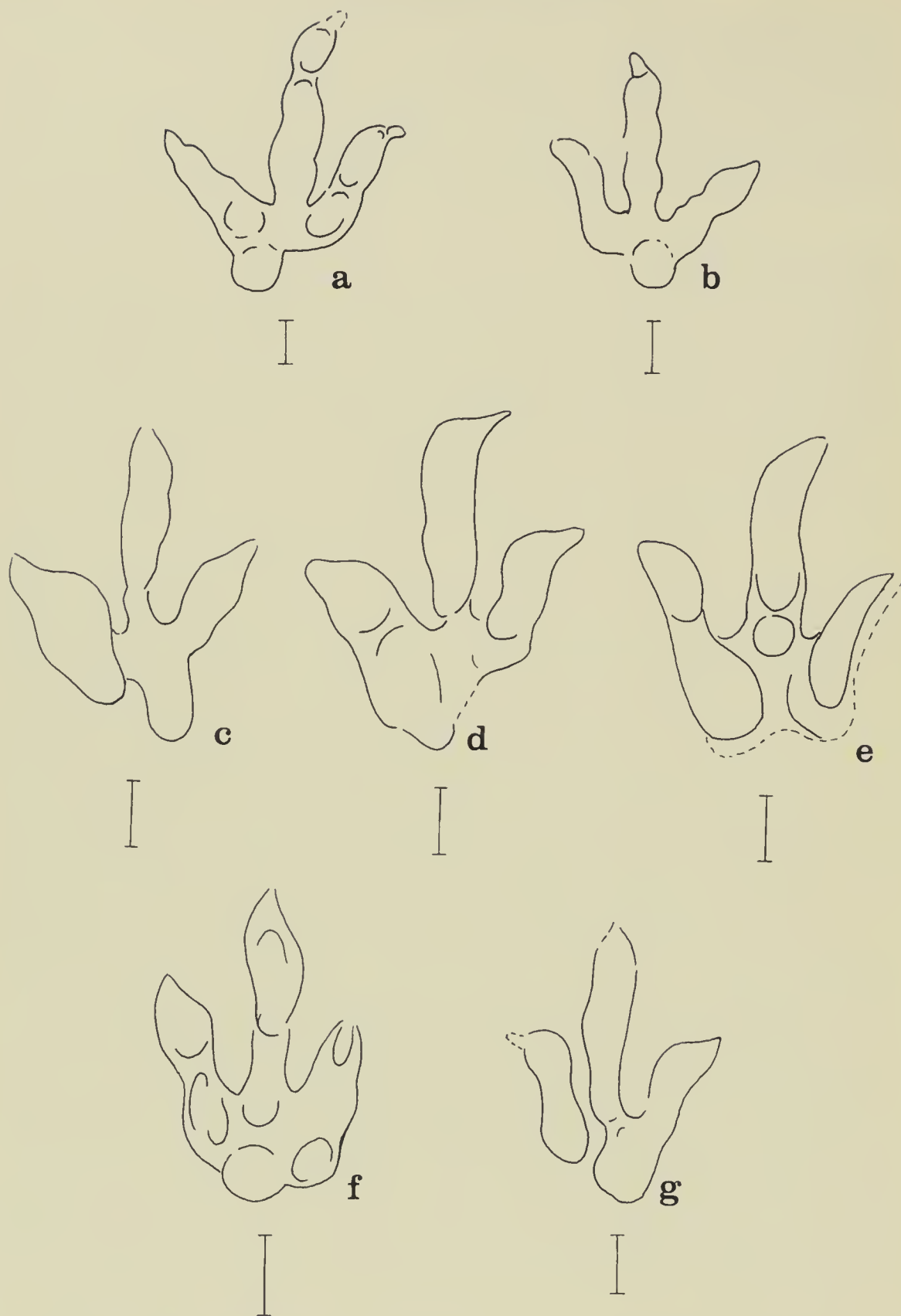


Fig. 1 — Small Theropod footprints, Teguidat'n Tagait. (a-b) K1-K2; (c-d) X3-X4; (e) B2; (f-g) W1-W2.

The footprints from Teguidat'n Tagait are marked by a letter identifying the sequence followed by a progressive number.

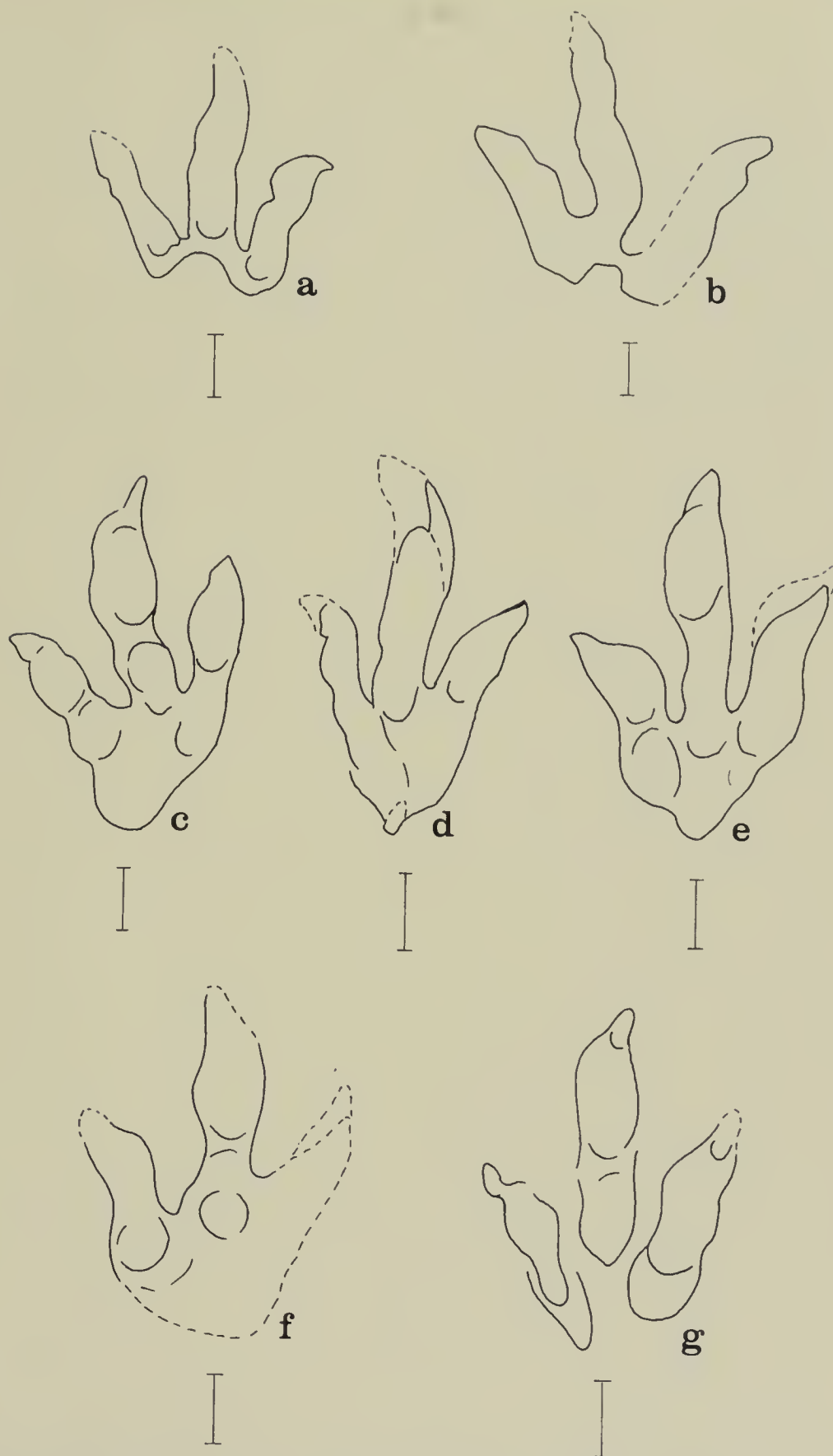


Fig. 2 — Small Theropod footprints, Teguidat'n Tagait. (a-b) R7-R8; (c-g) L4-L13-L2-L9-L8.

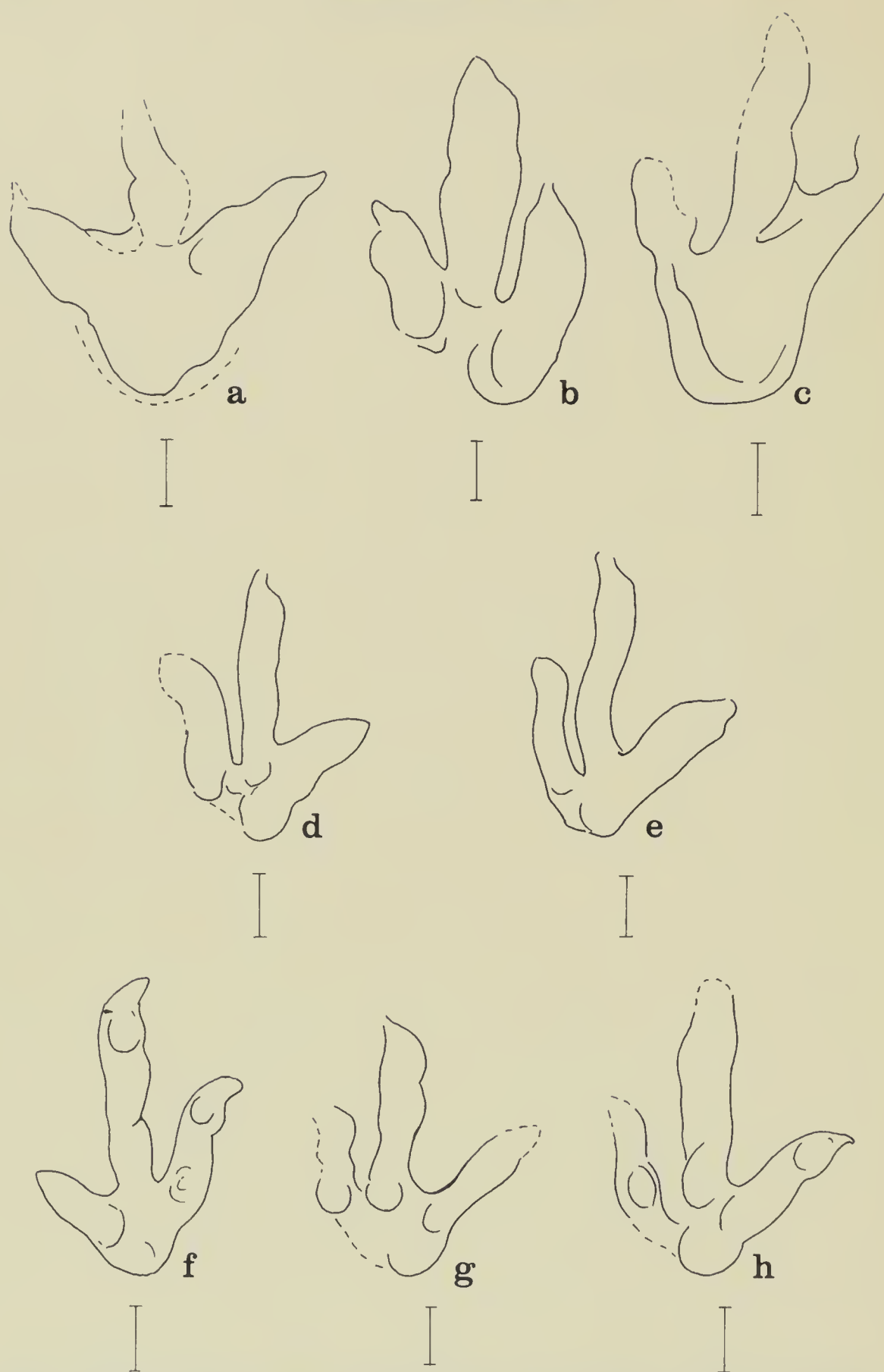


Fig. 3 – Small Theropod footprints, Teguidat'n Tagait. (a-b) Y20-Y3; (c) C4; (d-h) U3-U9-U10-U17-U13.



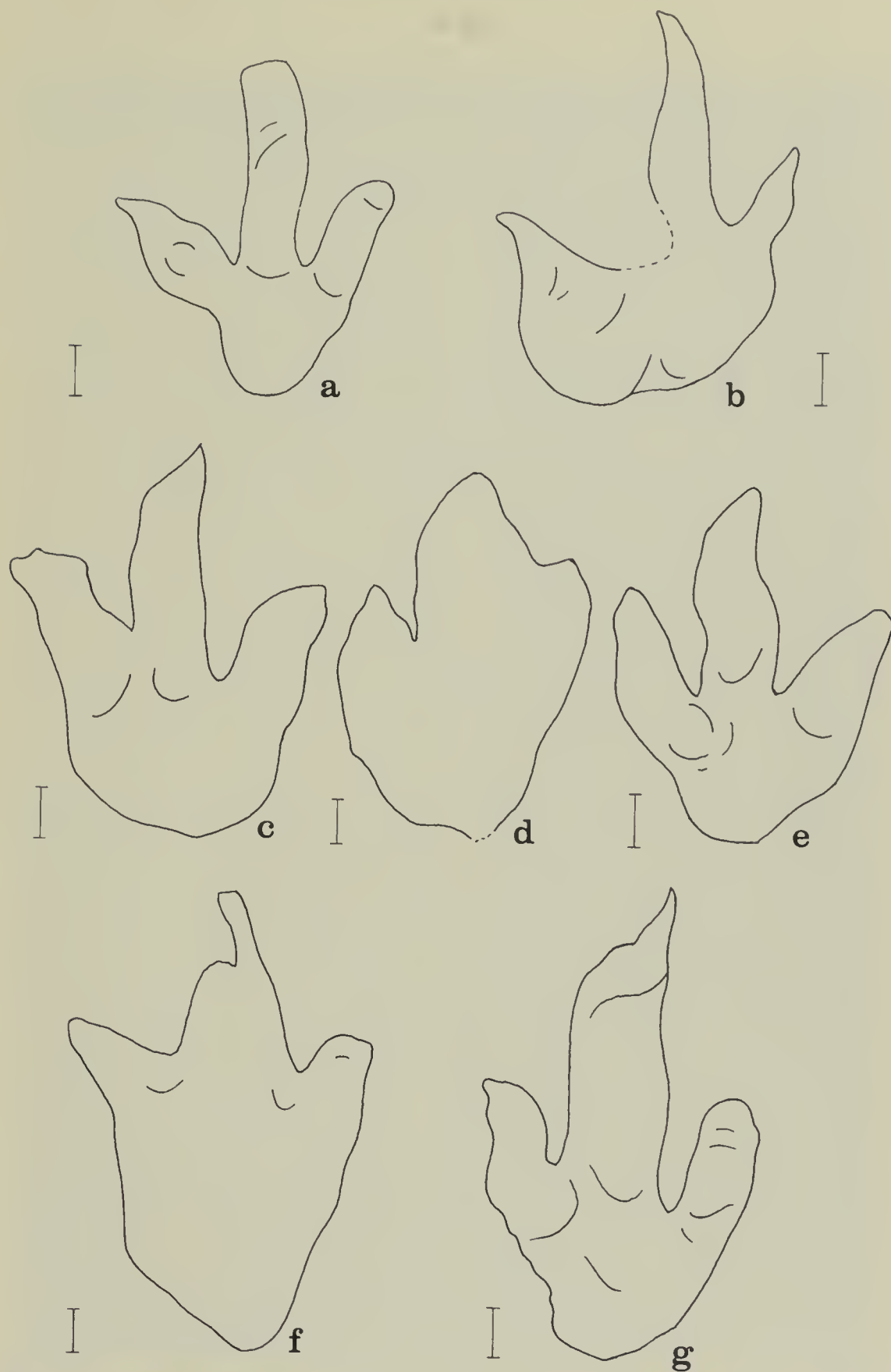


Fig. 4 — Carnosaur footprints, Ain Salem (AS1 and AS2, see text). (a, b and e) AS1, isolated undertracks; (c, d, f and g) AS2, footprints from the same sequence.

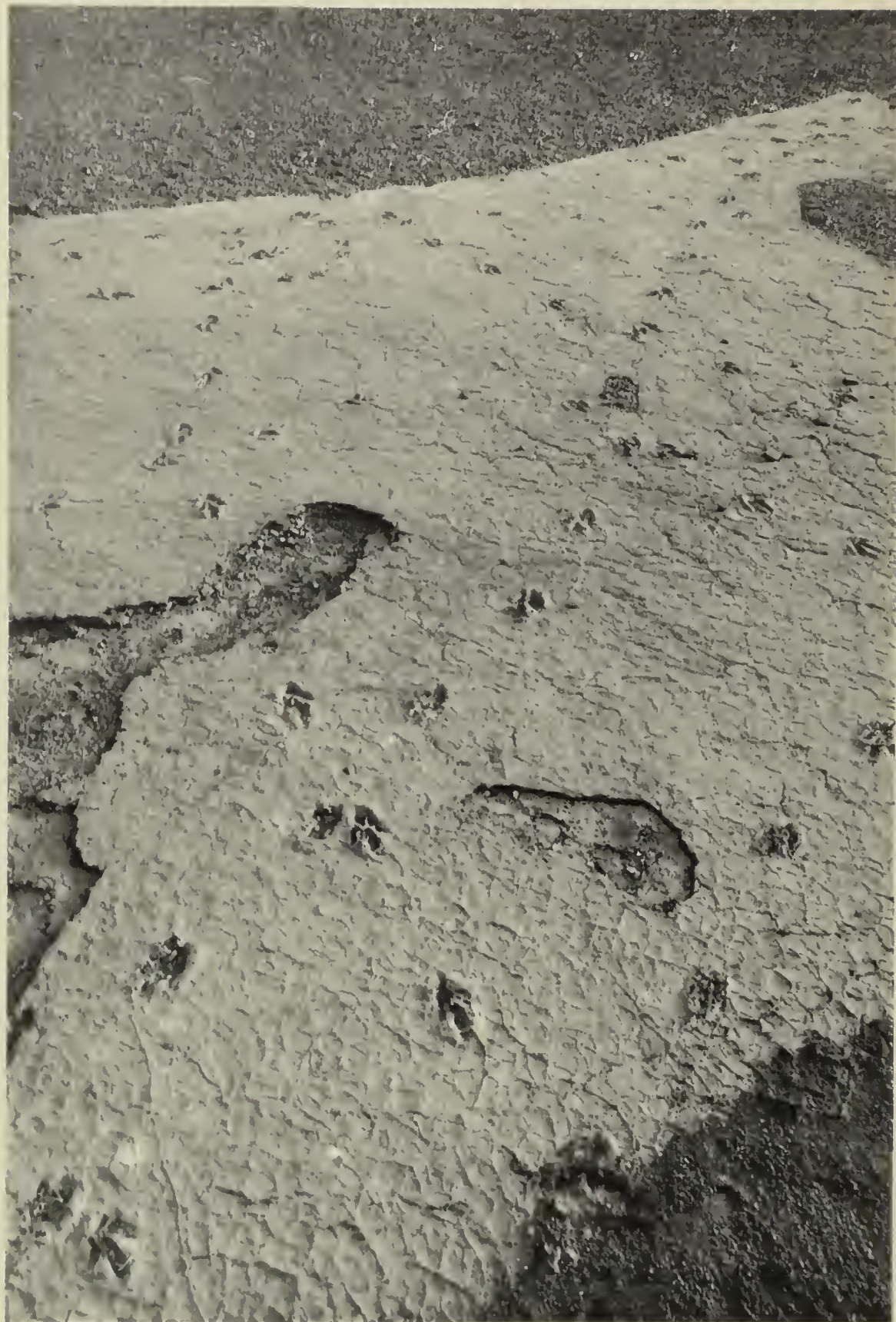
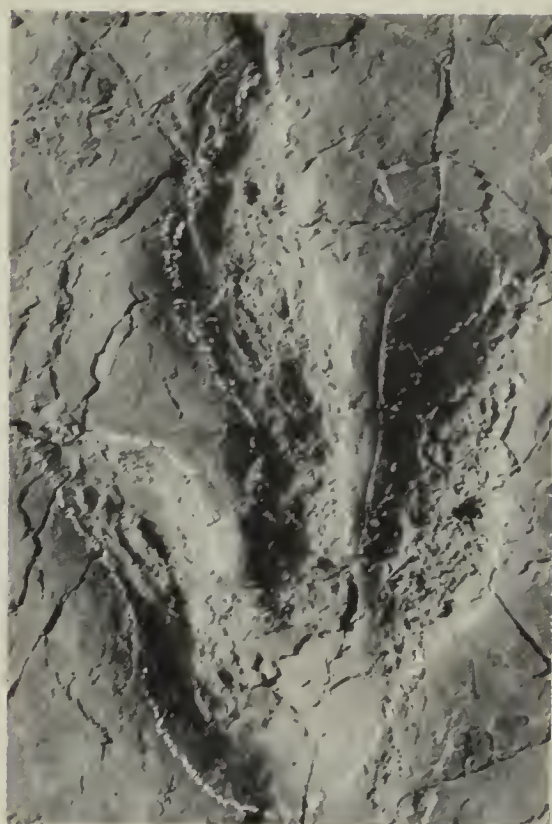


Fig. 5 — Teguidat'n Tagait: partial view of the outcrop with small Theropod footprints.

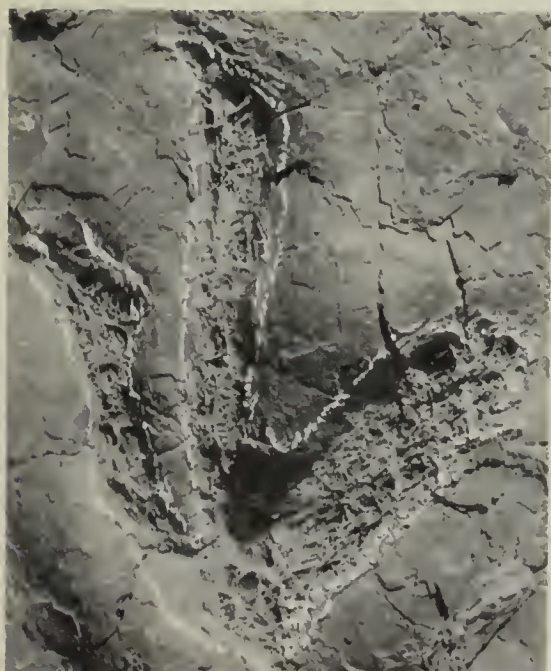




6a



6b

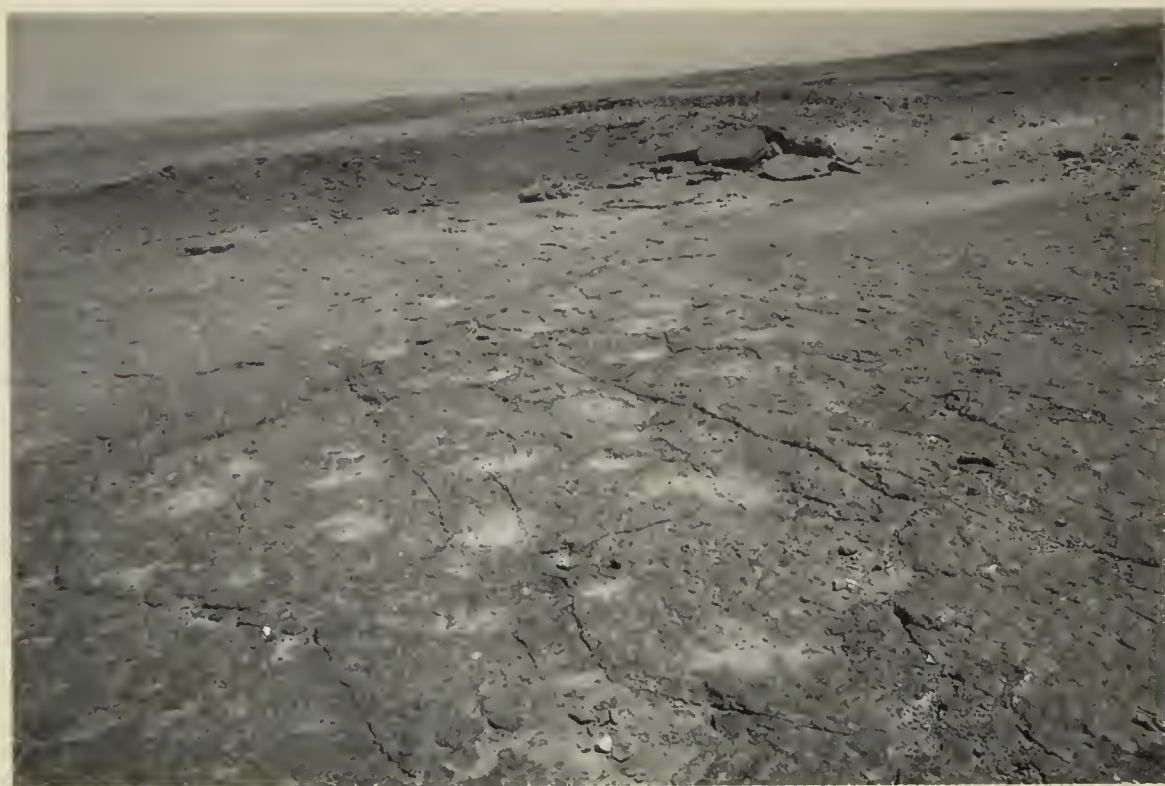


6c

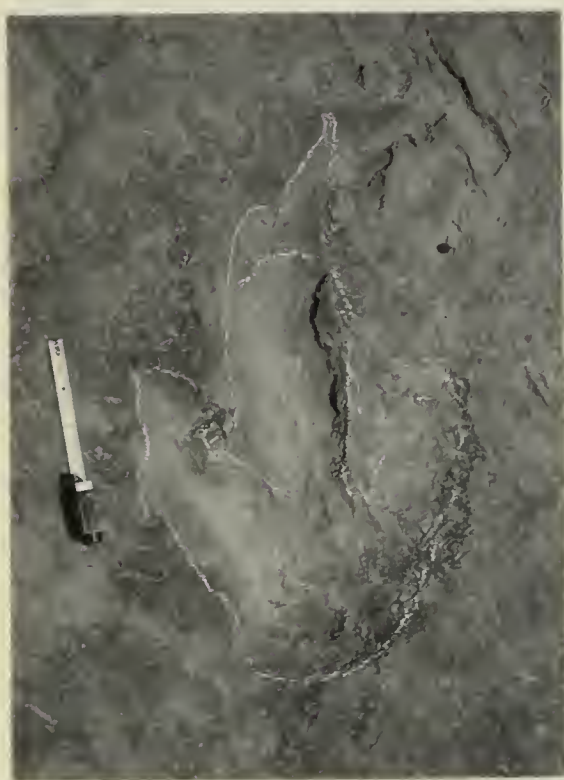


6d

Fig. 6 — Teguidat'n Tagait: some of the small Theropod footprints. a) L13; b) L8; c) U9; d) B3.



7a



7b



7c

Fig. 7 – Ain Salem 1: (a) partial view of the outcrop; (b-c) footprints of Carnosaur of the same sequence: b) left foot, c) right foot.